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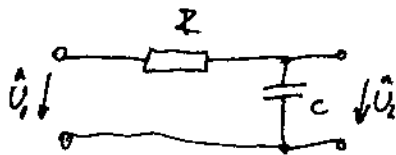
rápčet - 2 absence, ale budou úholý
3 měření (zpracování)

Tablady teorie obvodů
1, 6, 7, 8, 9. týden skripta 1.
ostatní 2.

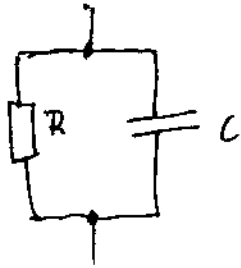
laborky 9, 11, 13?

<http://pitbul.wz.cz>

$$u(t) = 150 \sin 314t \quad \hat{=} \quad 150 e^{j0}$$

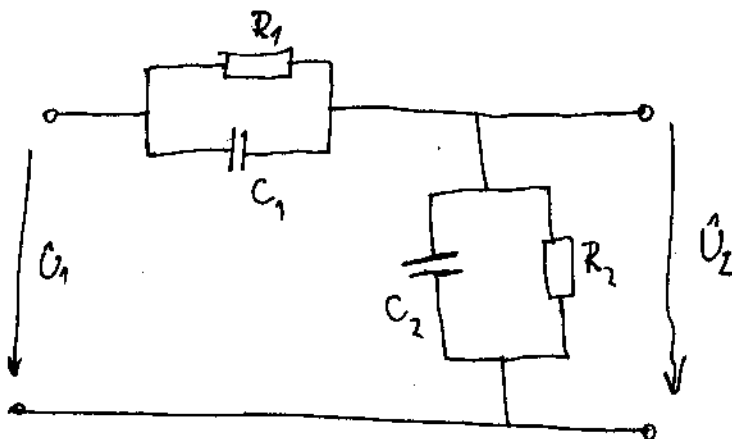


$$\hat{p} = \frac{\hat{U}_2}{\hat{U}_1} = \frac{\frac{1}{j\omega C}}{R + \frac{1}{j\omega C}}$$



$$\hat{z} = \frac{1}{\frac{1}{R} + j\omega C} = \frac{R}{1 + j\omega CR}$$

Ú 5.2.4



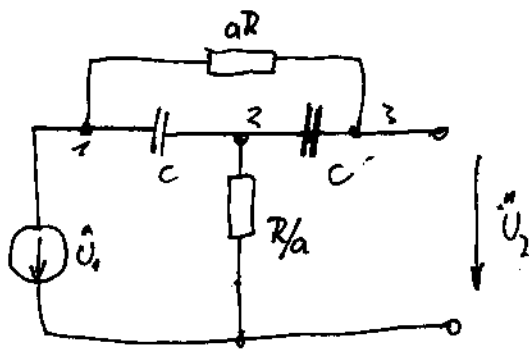
aby dělit napětí
byl frekvenčně
nezávislý

$$\begin{aligned} p = \frac{U_2}{U_1} &= \frac{\frac{1}{\frac{1}{R_2} + j\omega C_2}}{\frac{1}{\frac{1}{R_2} + j\omega C_2} + \frac{1}{\frac{1}{R_1} + j\omega C_1}} = \frac{\frac{1}{\frac{1 + j\omega C_2 R_2}{R_2}}}{\frac{1}{\frac{1 + j\omega C_2 R_2}{R_2}} + \frac{1}{\frac{1 + j\omega C_1 R_1}{R_1}}} = \\ &= \frac{\frac{R_2}{1 + j\omega C_2 R_2}}{\frac{R_2(1 + j\omega C_1 R_1) + R_1(1 + j\omega C_2 R_2)}{(1 + j\omega C_1 R_1)(1 + j\omega C_2 R_2)}} = \frac{R_2(1 + j\omega C_1 R_1)}{R_1(1 + j\omega C_2 R_2) + R_2(1 + j\omega C_1 R_1)} \end{aligned}$$

musí být $C_1 R_1 = C_2 R_2$

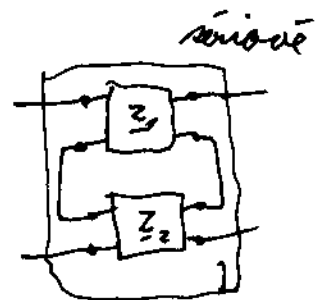
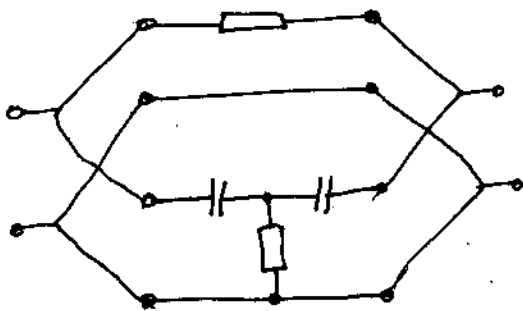
přenos pak $p = \frac{R_2}{R_1 + R_2}$

5.2.6

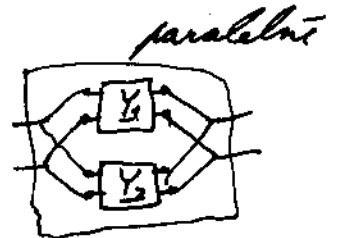


na DŮ udělat pomocí transformací

jinak přepnutí dvojbraní



$$Z = Z_1 + Z_2$$



$$Y = Y_1 + Y_2$$

$$P = \frac{\hat{U}_2}{\hat{U}_1} = \frac{1}{A_{11}} = -\frac{Y_{21}}{Y_{22}} = *$$

$$Y = \begin{bmatrix} \dots & \dots \\ -\frac{1}{aR} & \frac{1}{aR} \end{bmatrix} + \begin{bmatrix} \dots & \dots \\ \frac{-(-\omega^2 C^2)}{j\omega 2C + \frac{a}{R}} & \frac{j\omega C(\frac{a}{R} + j\omega C)}{j\omega 2C + \frac{a}{R}} \end{bmatrix} \Rightarrow$$

$$\Rightarrow Y_{21} = \frac{aR\omega^2 C^2 - j\omega 2C - \frac{a}{R}}{(j\omega 2C + \frac{a}{R}) \cdot aR}$$

$$Y_{22} = \frac{j\omega CaR(\frac{a}{R} + j\omega C) + j\omega 2C + \frac{a}{R}}{(j\omega 2C + \frac{a}{R}) aR}$$

$$* = -\frac{aR\omega^2 C^2 - j\omega 2C - \frac{a}{R}}{j\omega C a^2 - \omega^2 C^2 aR + j\omega 2C + \frac{a}{R}} = -\frac{\omega^2 C^2 R^2 - j\omega 2 \frac{CR}{a} - 1}{1 - \omega^2 R^2 C^2 + j\omega RCa + j\omega^2 \frac{RC}{a}} =$$

$$= \frac{1 - \omega^2 C^2 R^2 + j\omega \frac{CR}{a}}{1 - \omega^2 C^2 R^2 + j\omega RC \left(\frac{a^2 + 2}{a} \right)}$$

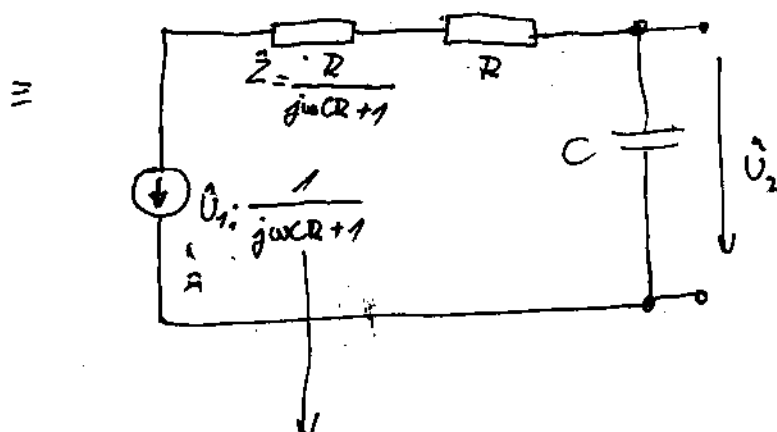
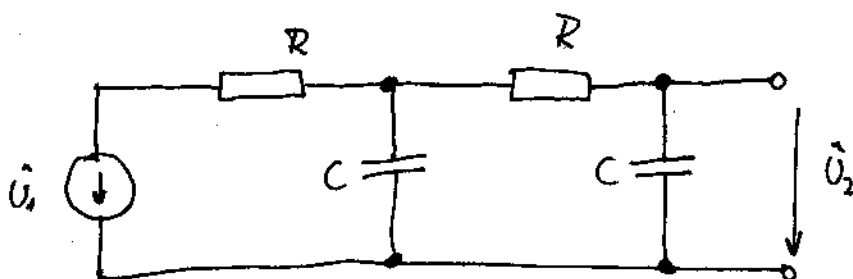
určit, aby $\hat{U}_2$ refoři $\hat{U}_1$ $\Leftrightarrow \hat{U}_2 \in \mathbb{R}$

$$\Leftrightarrow (1 - \omega^2 R^2 C^2) = 0$$

$$\Rightarrow \omega^2 = \frac{1}{R^2 C^2} \Rightarrow \omega = \frac{1}{RC}; \quad \#$$

$$\underline{\underline{\mathcal{P}(\omega_0 = \frac{1}{RC}) = \frac{2}{a^2 + 2}}}$$

5.2.7



$$\mathcal{P} = \frac{\frac{1}{j\omega C} \cdot \frac{1}{j\omega CR + 1}}{\frac{R}{j\omega CR + 1} + R + \frac{1}{j\omega C}} = \frac{\frac{1}{j\omega C(j\omega CR + 1)}}{\frac{j\omega CR + j\omega CR + 1 + j\omega CR(j\omega CR + 1)}{j\omega C(j\omega CR + 1)}} =$$

$$= \frac{1}{3j\omega CR - \omega^2 C^2 R^2 + 1}$$

• určit, aby fázový posuv byl
 $1 - \omega^2 C^2 R^2 = 0$
 $\omega^2 = \frac{1}{C^2 R^2} \quad \omega = \frac{1}{CR}$

$$R = 1 \text{ k}\Omega$$

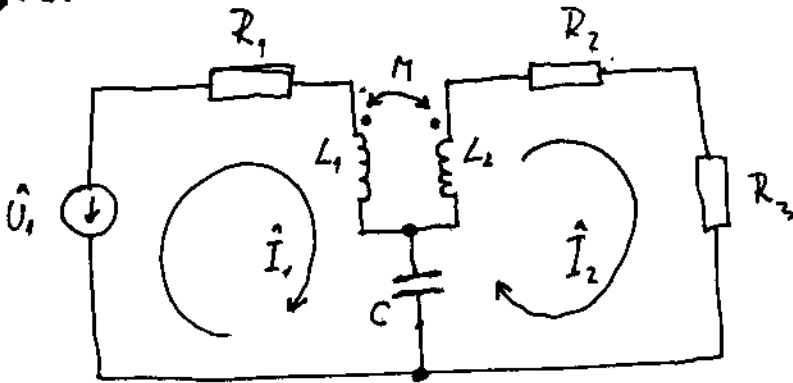
$$C = 1 \mu\text{F}$$

- axetil modul p\u0107enosu

$$P\left(\frac{1}{CR}\right) = \frac{1}{3\omega CR} = \underline{\underline{\frac{1}{3}}}$$

$$\omega = \frac{1}{CR} = 10^3$$

U 5.2.10



$$\hat{I}_1: -\hat{U}_s + R_1 \hat{I}_1 + j\omega L_1 \hat{I}_1 - j\omega M \hat{I}_2 + \frac{1}{j\omega C} (\hat{I}_1 - \hat{I}_2) = 0$$

$$\hat{I}_2: R_2 \hat{I}_2 + R_3 \hat{I}_2 + \frac{1}{j\omega C} (\hat{I}_2 - \hat{I}_1) + j\omega L_2 \hat{I}_2 - j\omega M \hat{I}_1 = 0$$

$$(1) \hat{I}_1 (R_1 + j\omega L_1 + \frac{1}{j\omega C}) - \hat{I}_2 (j\omega M + \frac{1}{j\omega C}) - \hat{U}_s = 0$$

$$(2) -\hat{I}_1 (\frac{1}{j\omega C} - j\omega M) + \hat{I}_2 (R_2 + R_3 + \frac{1}{j\omega C} + j\omega L_2) = 0$$

$$\hat{I}_1 \text{ z (2)} \quad \hat{I}_1 = \frac{\hat{I}_2 (R_2 + R_3 + \frac{1}{j\omega C} + j\omega L_2)}{\frac{1}{j\omega C} - j\omega M}$$

a dostan\u00e9 do (1)

$$\frac{\hat{I}_2 (R_2 + R_3 + \frac{1}{j\omega C} + j\omega L_2) \cdot (R_1 + j\omega L_1 + \frac{1}{j\omega C})}{\frac{1}{j\omega C} - j\omega M} - \hat{I}_2 (j\omega M + \frac{1}{j\omega C}) - \hat{U}_s = 0$$

DODO

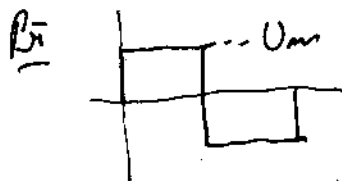
$$\hat{I}_2 \frac{(R_2 + R_3)j\omega C - \omega^2 L_2 C + 1}{1 + \omega^2 MC} \left(\frac{R_1 + j\omega C R_1 - \omega^2 C L_1}{j\omega C} \right) - \hat{I}_2 \left(\frac{1 - \omega^2 MC}{j\omega C} \right) - \hat{U}_s = 0$$

$$f(t) = \frac{a_0}{2} + \sum_{k=1}^{\infty} (a_k \cos k\omega_0 t + b_k \sin k\omega_0 t)$$

$$a_k = \frac{2}{T} \int_0^T f(t) \cos k\omega_0 t dt, \quad b_k = \frac{2}{T} \int_0^T f(t) \sin k\omega_0 t dt$$

$$f(t) = B_0 + \sum_{k=1}^{\infty} B_k \sin(k\omega_0 t + \varphi_k)$$

$$B_k^2 = a_k^2 + b_k^2; \quad B_0 = \frac{a_0}{2}; \quad \text{bzw. } \varphi_k = \frac{a_k}{b_k}$$



(antiperiod. periodisch,
bzw. / der $T/2$)

$$f(t) = \sum_{k=-\infty}^{\infty} A_k e^{jk\omega_0 t}$$

$$A_k = \frac{2}{T} \int_0^{T/2} U_m e^{-jk\omega_0 t} dt = \frac{2U_m}{-jk\omega_0 T} \left[e^{-jk\omega_0 t} \right]_0^{T/2} =$$

$$\omega_0 = \frac{2\pi}{T}$$

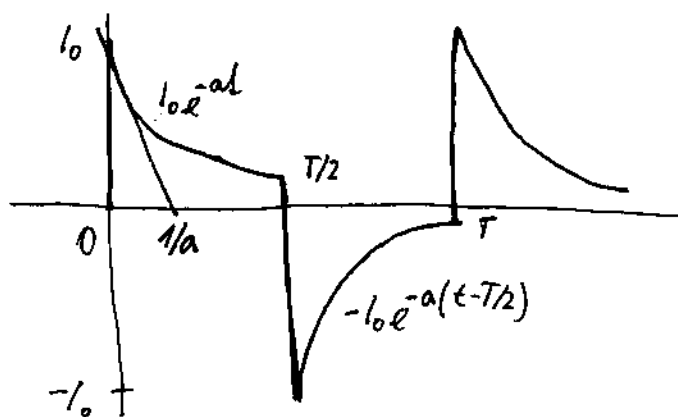
$$= \frac{U_m}{-j\pi k} \left(\underbrace{e^{-jk\pi} - 1}_{\substack{k \text{ gerade} -2 \\ k \text{ ungerade} 0}} \right) = \frac{2U_m}{j\pi k} \quad \text{pro } k \text{ gerade}$$

0 pro k ungerade

$$A_k = \frac{a_k - jb_k}{2} \Rightarrow b_k = \frac{4U_m}{\pi k}$$

$$f(t) = \sum_{k=1}^{\infty} \frac{4U_m}{\pi k} \sin k\omega_0 t$$

1.1.6



$$aT = 10$$

$$A_h = \frac{2I_0}{T} \int_0^{T/2} I_0 e^{-at} e^{-jkw_0 t} dt = \frac{2}{T} I_0 \int_0^{T/2} e^{-at-jkw_0 t} dt =$$

$$= \frac{2}{T} I_0 \left[\frac{e^{-at-jkw_0 t}}{-a-jkw_0} \right]_0^{T/2} = \frac{2 I_0 (e^{-aT/2-jk\pi} - 1)}{T(-a-jkw_0)} =$$

$$= \frac{2 I_0}{T(-a-jkw_0)} = \frac{I_0}{5+jk\pi} \cdot \frac{5-jk\pi}{5-jk\pi} = \frac{I_0(5-jk\pi)}{25+k^2\pi^2}$$

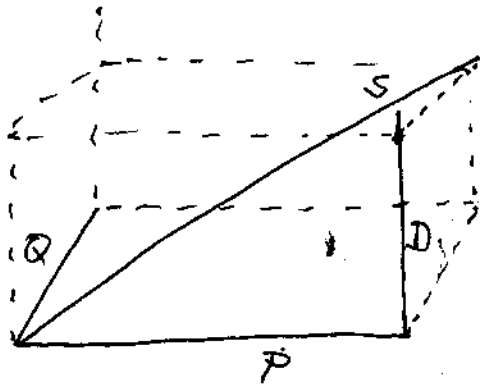
$$B_h = \sqrt{\frac{I_0^2(5^2+k^2\pi^2)}{(25+k^2\pi^2)^2}} = \frac{I_0}{\sqrt{25+k^2\pi^2}}$$

$$\phi_h = \arctan \frac{-k\pi}{5}$$

$$i(t) = \frac{I_0}{\sqrt{25+k^2\pi^2}} \sin(\omega_0 t + \arctan \frac{-k\pi}{5})$$

$$\begin{aligned}
 U_{ef} &= \sqrt{U_{ef0}^2 + U_{ef1}^2 + \dots + U_{efN}^2} \\
 &= \sqrt{U_0^2 + \left(\frac{U_{m1}}{\sqrt{2}}\right)^2 + \dots + \left(\frac{U_{mN}}{\sqrt{2}}\right)^2} = \\
 &= \sqrt{U_0^2 + \frac{U_{m1}^2}{2} + \dots + \frac{U_{mN}^2}{2}}
 \end{aligned}$$

$$I_{ef} = \dots$$



$$D^2 = S^2 - P^2 - Q^2$$

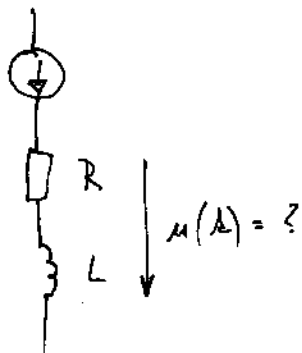
$$S = I_{ef} U_{ef}$$

$D\bar{U}$ 1.1.8

$$P = U_0 I_0 + \frac{1}{2} \sum_{k=1}^{\infty} \operatorname{Re}(\hat{I}_{mk} \hat{U}_{mk}^*)$$

$$Q = \frac{1}{2} \sum_{k=1}^{\infty} \operatorname{Im}(\hat{I}_{mk} \hat{U}_{mk}^*)$$

1.2.1.



$$R = 50 \Omega, L = 0,12 \text{ H}, \omega_0 = 314 \text{ rad/s}$$

$$i(t) = 0,8 + 2,5 \sin \omega_0 t + 0,5 \sin \left(2\omega_0 t + \frac{\pi}{12} \right) + 1,5 \sin \left(3\omega_0 t - \frac{\pi}{6} \right) \quad [\text{A}]$$

$$\hat{Z}_0 = 50 \Omega$$

$$\hat{Z}_1 = R + j\omega_0 L = 50 + j37,68 = 62,6 e^{j0,646}$$

$$\hat{Z}_2 = R + j2\omega_0 L = 50 + j75,36 = 90,4 e^{j0,985}$$

$$\hat{Z}_3 = R + j3\omega_0 L = 50 + j113,04 = 123,6 e^{j1,154}$$

$$\hat{U}_0 = 0,8 \cdot 50 = 40 \quad [\text{V}]$$

$$\hat{U}_1 = 2,5 \cdot 62,6 e^{j0,646} = 157 e^{j0,646} \quad [\text{V}]$$

$$\hat{U}_2 = 0,5 e^{j\frac{\pi}{12}} \cdot 90,4 e^{j0,985} = 45,2 e^{j1,247} \quad [\text{V}]$$

$$\hat{U}_3 = 1,5 e^{j\frac{\pi}{6}} \cdot 123,6 e^{j1,154} = 185,4 e^{j1,630} \quad [\text{V}]$$

$$u(t) = 40 + 157 \sin(\omega_0 t + 0,646) + 45,2 \sin(2\omega_0 t + 1,247) + 185,4 \sin(3\omega_0 t + 1,630)$$

$$U_{ef} = \sqrt{40^2 + \left(\frac{157}{\sqrt{2}}\right)^2 + \left(\frac{45,2}{\sqrt{2}}\right)^2 + \left(\frac{185,4}{\sqrt{2}}\right)^2} = 179,26$$

$$I_{ef} = \sqrt{0,8^2 + \frac{2,5^2}{2} + \frac{0,5^2}{2} + \frac{1,5^2}{2}} = 2,24$$

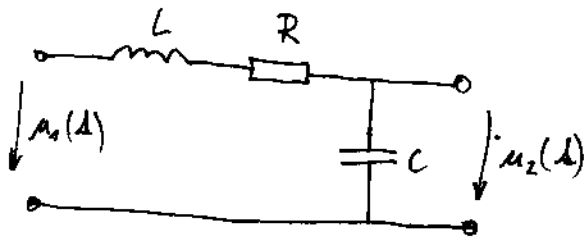
$$S = U_{ef} \cdot I_{ef}$$

$$P = U_0 I_0 + \sum_{i=1}^3 \operatorname{Re} \left\{ \frac{\hat{U}_i \hat{I}_i^*}{2} \right\}$$

$$P = 40 \cdot 0,8 + \frac{1}{2} (157 \cdot 2,5 \cos 0,646 + 45,2 \cdot 0,5 \cos 0,985 + 185,4 \cdot 1,5 \cos 1,154)$$

$$Q = \sum_{i=1}^3 \operatorname{Im} \left\{ \frac{\hat{U}_i \hat{I}_i^*}{2} \right\}$$

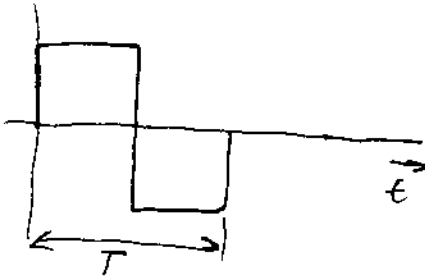
1.2.3



$$\omega_0^2 = \frac{1}{LC}$$

$$Q = \frac{1}{\omega_0 CR}$$

$$Q \stackrel{?}{=} \text{aby } \frac{U_{m23}}{U_{m21}} < 0,01$$



$$u_1(t) = \frac{4U_m}{\pi} \sum_{k=1}^{\infty} \frac{1}{k} \sin k\omega_0 t$$

h. Lichte

$$\frac{\hat{U}_2}{\hat{U}_1} = \frac{\frac{1}{j\omega C}}{R + j\omega L + \frac{1}{j\omega C}} = \frac{1}{j\omega CR - k^2\omega_0^2 LC + 1} = \frac{j\omega CR - k^2\omega_0^2 LC - j\omega CR}{(j\omega CR)^2 + (1 - k^2\omega_0^2 LC)^2}$$

$$\left| \frac{\hat{U}_2}{\hat{U}_1} \right| = \frac{1}{\sqrt{(j\omega CR)^2 + (1 - k^2\omega_0^2 LC)^2}} = \frac{1}{\sqrt{\underbrace{(j\omega CR)^2}_{\frac{1}{Q^2}} + \underbrace{(1 - k^2\omega_0^2 LC)^2}_{\frac{1}{LC}}}}$$

$$= \frac{1}{\sqrt{\left(\frac{k}{Q}\right)^2 + (1 - k^2)^2}}$$

$$\frac{U_{m23}}{U_{m21}} = \frac{\frac{4U_m}{\pi} \cdot \sqrt{\left(\frac{3}{Q}\right)^2 + 64}}{\frac{4U_m}{\pi} \cdot \frac{1}{\sqrt{\frac{1}{Q^2}}}} = \frac{\sqrt{\left(\frac{3}{Q}\right)^2 + 64}}{3 \cdot Q}$$

$$= \frac{1}{3Q \cdot \sqrt{\left(\frac{3}{Q}\right)^2 + 64}} < 0,01$$

$$\frac{1}{3Q \sqrt{\left(\frac{3}{Q}\right)^2 + 64}} < 0,01$$

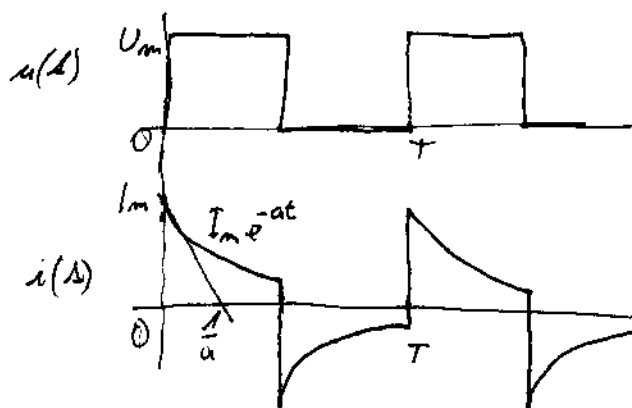
$$\frac{1}{9Q^2 \cdot \left(\frac{9}{Q^2} + 64\right)} < 10^{-4}$$

$$81 + 576 Q^2 > 10^4$$

$$Q^2 > \frac{10^4 - 81}{576}$$

$$Q > 4,15$$

1.2.4



napietí na odporu

$$U_m = 120 \text{ V}$$

$$I_m = 2 \text{ mA}$$

$$a = 4,2 \text{ s}^{-1}$$

$$T = 0,02 \text{ s}$$

odebírá proud

co je to za obvod?

$$\hat{z} = \frac{\hat{U}}{\hat{I}}$$

$$A_k(\omega) = \frac{1}{T} \int_0^{\frac{T}{2}} U_m \cdot e^{-jk\omega t} dt =$$

$$\omega_0 = \frac{2\pi}{T}$$

$$= \frac{U_m}{-jk\omega_0 T} \cdot \left[e^{-jk\omega_0 t} \right]_0^{\frac{T}{2}} = \frac{U_m}{-jk\omega_0 T} \cdot \left[e^{-jk\pi} - 1 \right] = \frac{2U_m}{jk\omega_0 T} \text{ pro k lich}$$

$$k \text{ sudé } (e^{-jk\pi} - 1) = 0$$

$$k \text{ liché } (e^{-jk\pi} - 1) = -2$$

$$A_k(\omega) = \frac{2}{T} \int_0^{\frac{T}{2}} I_0 \cdot e^{-t(a+jk\omega_0)} dt = \frac{2I_0}{-T(a+jk\omega_0)} \cdot \left[e^{-t(a+jk\omega_0)} \right]_0^{\frac{T}{2}} =$$

$$= \frac{2I_0}{-T(a+jk\omega_0)} \cdot \left(e^{-\frac{T}{2}(a+jk\frac{2\pi}{T})} - 1 \right) = \frac{2I_0}{-T(a+jk\omega_0)} \cdot \left(e^{-\frac{T_0}{2} \cdot e^{-jk\pi}} - 1 \right)$$

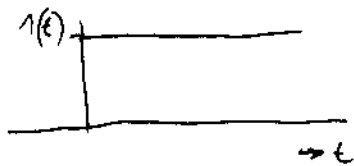
$$k \text{ liché } = -1$$

$$A_h(s) = \frac{2I_0}{T(a + jk\omega_0)} \cdot \left(e^{-\frac{aT}{2}} + 1 \right)$$

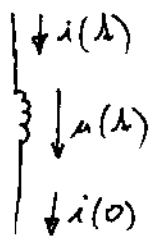
$$\begin{aligned} \hat{Z} = \frac{\hat{U}}{\hat{I}} &= \frac{A_h(\omega)}{A_h(1)} = \frac{2U_m}{jk\omega_0 T} \cdot \frac{T(a + jk\omega_0)}{2I_0 e^{-\frac{aT}{2}}} = \\ &= \frac{U_m(a + jk\omega_0)}{jk\omega_0 \cdot I_0 \left(e^{-\frac{aT}{2}} + 1 \right)} = \frac{U_m a}{jk\omega_0 I_0 \left(e^{-\frac{aT}{2}} + 1 \right)} + \frac{U_m \cancel{jk\omega_0}}{\underbrace{I_0 \left(e^{-\frac{aT}{2}} + 1 \right)}_{=R}} = \\ &\quad \frac{1}{jk\omega_0 C} + R \end{aligned}$$

$$C = \frac{U_m a}{I_0 \left(e^{-\frac{aT}{2}} + 1 \right)}$$

DÚ 1.2.5



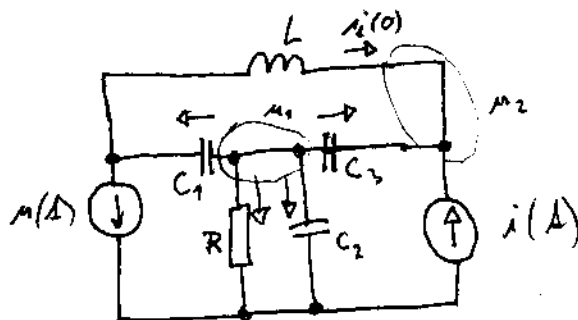
$$\mathcal{L}\{1(t)\} = \int_0^{\infty} 1(t) \cdot e^{-st} dt = \left[-\frac{e^{-st}}{s} \right]_0^{\infty} = 0 + \frac{1}{s} = \underline{\underline{\frac{1}{s}}}$$



$$i(t) = \frac{1}{L} \int_0^t u(\tau) d\tau + i(0)$$

$$u(t) = L \frac{di(t)}{dt}$$

3.4.2



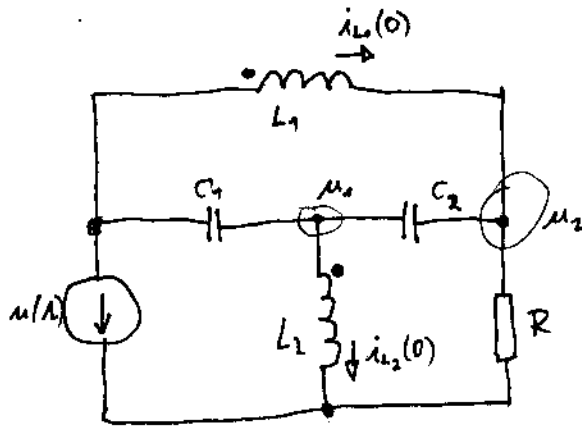
$$x_m = 4 - 1 - 1 = 2$$

$$x_i = 4 - 1 = 3$$

$$m_1: C_1 \frac{d}{dt} (u_1 - u) + \frac{u_1}{R} + C_2 \frac{du_1}{dt} + C_3 \frac{d}{dt} (u_1 - u_2) = 0$$

$$m_2: \frac{1}{L} \int (u_2 - u) d\tau - i_2(0) - i(t) + C_3 \frac{d}{dt} (u_2 - u_1) = 0$$

U 3.4.4



$$x_n = 4 - 1 - 1 = 2$$

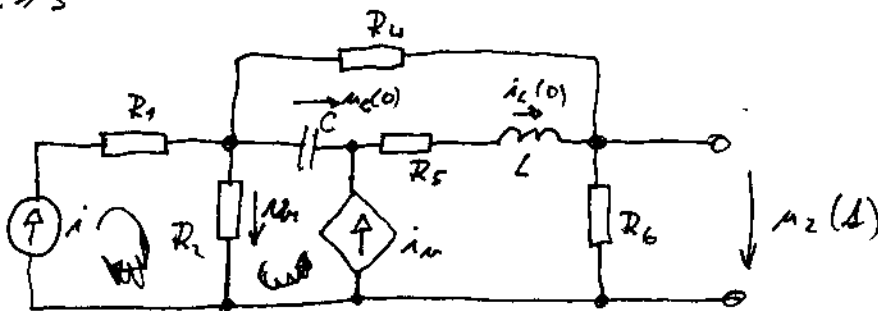
$$x_i = 3$$

$$i(t) = \Gamma_{L_1} \int_0^t (\mu_2 - \mu) d\tau - i_{L_1}(0) + \Gamma_{R_1} \int_0^t (-\mu_1) d\tau$$

$$\mu_1: C_1 \frac{d}{dt} (\mu_1 - \mu) + C_2 \frac{d}{dt} (\mu_1 - \mu_2) + \Gamma_{L_2} \int_0^t \mu_1 d\tau + i_{L_2}(0) + \Gamma_{R_1} \int_0^t (\mu - \mu_2) d\tau =$$

$$\mu_2: \frac{\mu_2}{R} + C_2 \frac{d}{dt} (\mu_2 - \mu_1) + \Gamma_{L_1} \int_0^t (\mu_2 - \mu) d\tau - i_{L_1}(0) + \Gamma_{R_1} \int_0^t -\mu_1 d\tau = 0$$

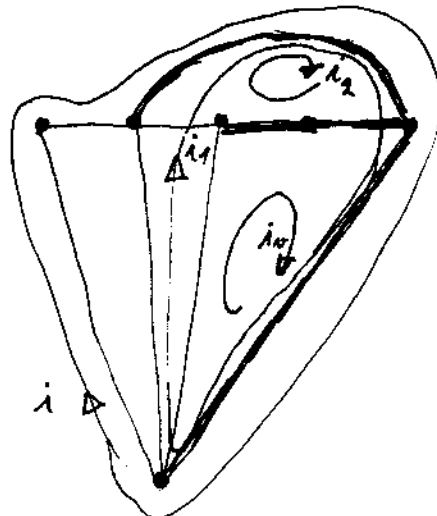
U 3.4.13



$$i_n = G u_n$$

$$x_n = 6 - 1 - 0 = 5$$

$$x_i = 4 - 2 = 2$$



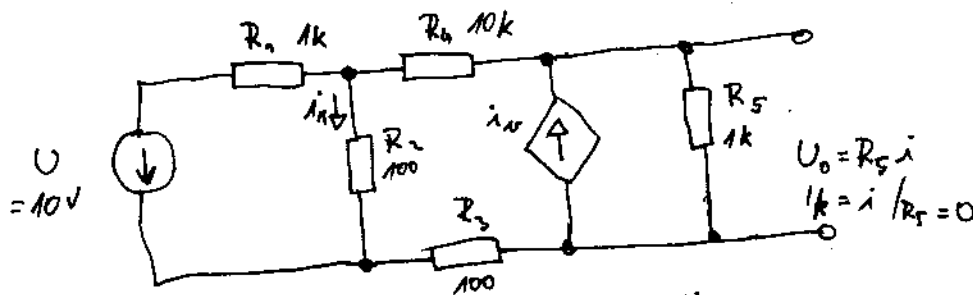
$$i_1: i_1 R_2 + (i_1 + i_2 + i_w) R_4 + (i_1 + i_w + i_w) R_6$$

$$i_2: (i_1 + i_2 + i) R_4 + L \frac{d}{dt} (i_2 - i_w) + (i_2 - i_w) R_5 +$$

$$+ \frac{1}{C} \int_0^t i_2 d\tau - u_c(0) = 0$$

$$i_w = G R_2 (-i_1)$$

Pa 3.2.7



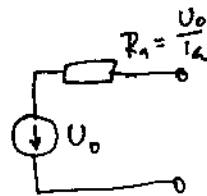
$$i_w = H i_n$$

$$H = -50$$

$$U_0 = R_5 i$$

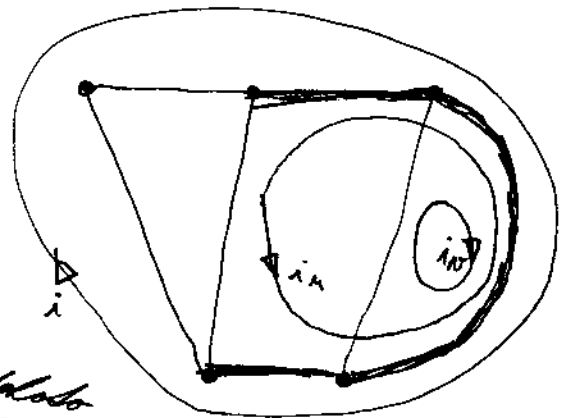
$$1k = i / R_5 = 0$$

mit Thévenin



$$x_u = 5 - 1 - 1 = 3$$

$$x_i = 3 - 1 = 2$$

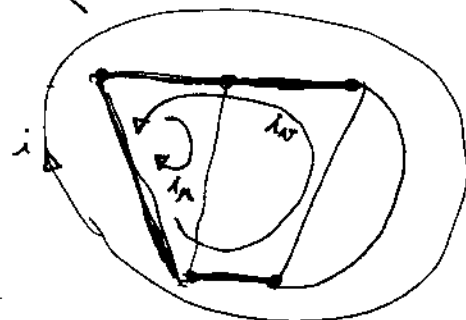


→ KVL

$$i: -U + \left(\frac{i + i_n - i_w}{R_1} \right) R_1 + (i - i_w) R_4 +$$

$$i R_5 + (i - i_w) R_3 = 0$$

$$i_w: -U + (i + i_n - i_w) R_1 + i_w R_2 = 0$$



$$-U + R_1 (i + i_n + 50 i_n) + R_4 (i + 50 i_n) + R_5 i + R_3 (i + 50 i_n) = 0$$

$$-U + R_1 (i + i_n + 50 i_n) + \dots i_n R_2 = 0$$

$$i(R_1 + R_4 + R_5 + R_2) + i_n(51R_1 + 50R_4 + 50R_3) = 0$$

$$iR_1 + i_n(51R_1 + R_2) = 0$$

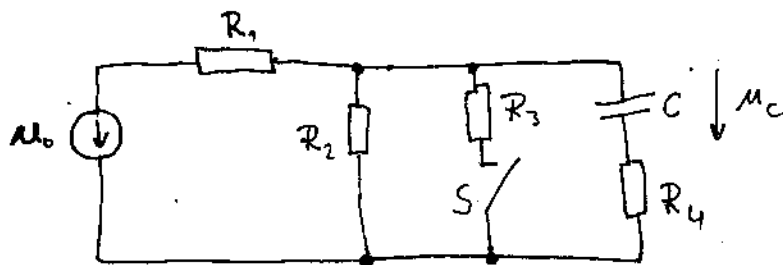
$$i(10^3 + 10^4 + 10^3 + 10^2) + i_n(51 \cdot 10^3 + 50 \cdot 10^4 + 50 \cdot 10^2) = 10$$

$$i \cdot 10^3 + i_n(51 \cdot 10^3 + 10^2) = 10$$

$$12100i + 55600i_n = 10$$

$$100i + 5110i_n = 10$$

dobitok + se reže superpozicií



$$u_0 = 10 \text{ V}$$

$$R_1 = 2 \text{ k}\Omega$$

$$R_2 = 2 \text{ k}\Omega$$

$$R_3 = 1 \text{ k}\Omega$$

$$R_4 = 1 \text{ k}\Omega$$

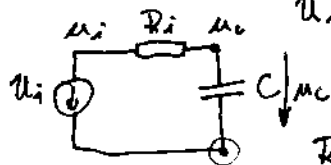
$$1) \quad \Delta \leq 0$$

$$u_c(t \leq 0) = u_0 \frac{R_2}{R_1 + R_2} = 5 \text{ V}$$

$$2) \quad \Delta > 0$$

Thévenin

$$u_i = u_0 \frac{R_2 \parallel R_3}{R_1 + R_2 \parallel R_3} = u_0 \frac{\frac{R_2 R_3}{R_2 + R_3}}{R_1 + \frac{R_2 R_3}{R_2 + R_3}} = 2,5 \text{ V}$$



$$R_i = R_4 + R_1 \parallel R_2 \parallel R_3 = 1,5 \text{ k}\Omega$$

$$u_c: \quad C \cdot \frac{du_c}{dt} + \frac{u_c - u_i}{R_i} = 0$$

$$R_i C u_c' + u_c = u_i$$

$$u_c = u_0 + u_p$$

$$R_i C u_c' + u_c = 0$$

$$R_i C \lambda + 1 = 0$$

$$\lambda = -\frac{1}{R_i C} = -666$$

$$u_0 = k \cdot e^{\lambda t} = \underline{k \cdot e^{-666t}}$$

$$u_p = u_c(\lambda \rightarrow \infty) = u_i$$

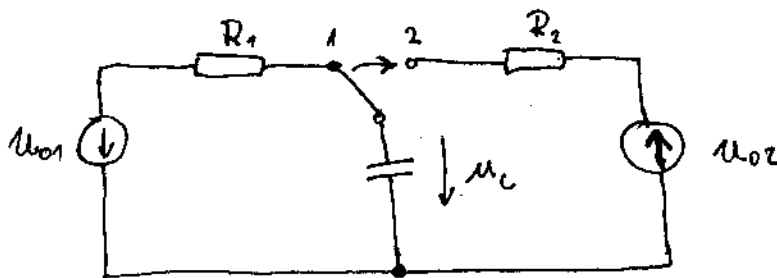
$$u = u_0 + u_p = k \cdot e^{-666t} + u_i$$

$$u_c(0) = k e^0 + 2,5$$

$$5 = u_c(0) = k + 2,5$$

$$k = 2,5$$

$$\underline{\underline{u_c = 2,5 e^{-666 t} + 2,5}}$$

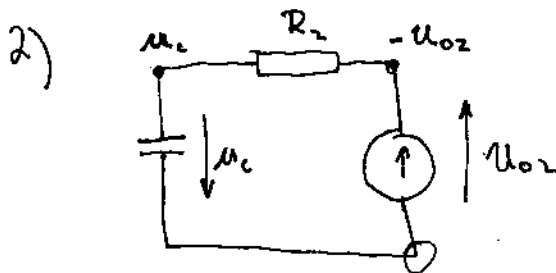


$$u_{o1} = 10V, u_{o2} = 5V, R_1 = 1k\Omega, R_2 = 2k\Omega, C = 10\mu F$$

$$u_c = ?$$

$$1) t \neq 0$$

$$u_c(t \neq 0) = u_{o1}$$



$$u_c: C \frac{du_c}{dt} + \frac{u_c + u_{o2}}{R_2} = 0$$

$$R_2 C u_c' + u_c = -u_{o2}$$

$$\text{Ans} \quad u_c = u_{c0} + u_{cp}$$

$$R_2 C \lambda + 1 = 0$$

$$\lambda = -\frac{1}{R_2 C}$$

$$u_{C0} = k \cdot e^{-\frac{1}{R_2 C} t}$$

$$u_C = u_C(\lambda \rightarrow \infty) = -u_{02}$$

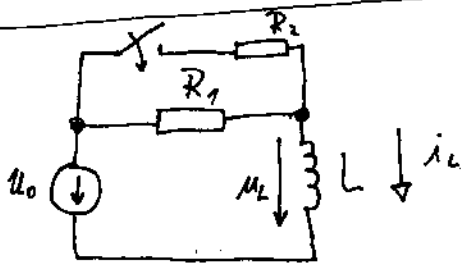
$$u_C = k \cdot e^{-\frac{1}{R_2 C} t} = u_{02}$$

$$u_{01} = u_{C0} = k - u_{02}$$

$$k = u_{01} + u_{02}$$

$$u_C = (u_{01} + u_{02}) \cdot e^{-\frac{1}{R_2 C} t} - u_{02}$$

$$u_C = 15 e^{-50t} - 5$$



$$u_0 = 10 \text{ V}$$

$$R_1 = 1 \text{ k}\Omega, R_2 = 2 \text{ k}\Omega$$

$$L = 1 \text{ H}$$

$$i_L, u_L = ?$$

$$1) \lambda \leq 0$$

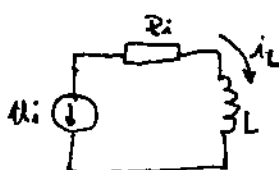
$$i_L(\lambda \leq 0) = \frac{u_0}{R_1} = 0,01 \text{ A}$$

$$2) \lambda > 0$$

$$R_i = R_1 \parallel R_2$$

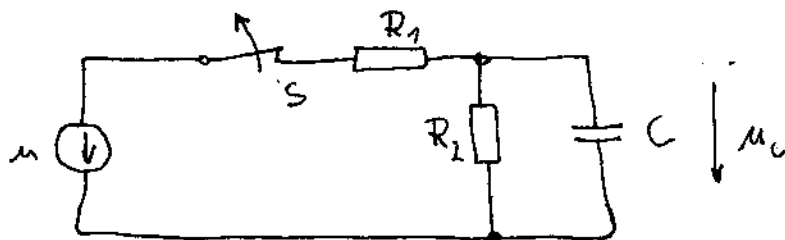
$$u_i = u_0$$

$$i_L: -u_i + R_i i_L + L \frac{di_L}{dt} = 0$$



$$i_L = -0,005 e^{-666t} + 0,015$$

$$u_L = L \frac{di_L}{dt} = 3,33 e^{-666 t}$$



$$u = 100 \sin\left(314t + \frac{\pi}{3}\right)$$

$$R_1 = R_2 = 1 \text{ k}\Omega$$

$$C = 6,366 \mu\text{F}$$

$$u_c = ? \quad \text{rozpne se S}$$

A) $t \geq 0$

$$\hat{U} = 100 e^{\frac{\pi}{3}}$$

$$\hat{U}_c = \hat{U} \cdot \frac{R_2 \parallel \frac{1}{j\omega C}}{R_1 + R_2 \parallel \frac{1}{j\omega C}} = \hat{U} \cdot \frac{\frac{R_2 \cdot \frac{1}{j\omega C}}{R_2 + \frac{1}{j\omega C}}}{R_1 + \frac{R_2 \cdot \frac{1}{j\omega C}}{R_2 + \frac{1}{j\omega C}}} = \hat{U} \cdot \frac{\frac{R_2}{j\omega C}}{R_1 R_2 + \frac{R_2}{j\omega C} + \frac{R_1}{j\omega C}} =$$

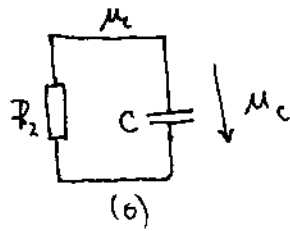
$$= \hat{U} \cdot \frac{R_2}{R_1 R_2 + R_2 + R_1 + j\omega C R_1 R_2} = \frac{1}{2+2j} \cdot 100 e^{\frac{\pi}{3} j} =$$

$$= \frac{100 e^{\frac{\pi}{3} j}}{2\sqrt{2} e^{\frac{\pi}{4} j}} = 35 e^{\frac{\pi}{12} j}$$

$$u_c(t) = 35 \sin\left(314t + \frac{\pi}{12}\right)$$

$$u_c(0) = 35 \sin \frac{\pi}{12} = 9,06 \text{ V}$$

$$2) \quad L = 0$$



$$u_c: \quad \frac{u_c}{R_2} + C \frac{du_c}{dt} = 0$$

$$CR_2 \frac{du_c}{dt} + u_c = 0$$

$$u_c = u_{c0} + u_{cf}$$

$$u_{c0} = k e^{\lambda t}$$

$$CR_2 \lambda + 1 = 0$$

$$\lambda = -\frac{1}{CR_2}$$

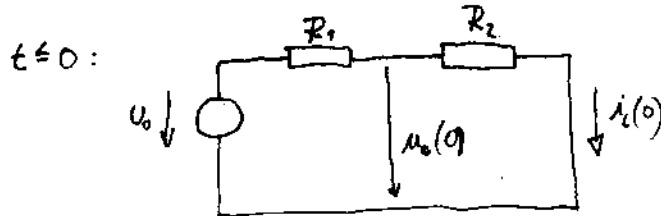
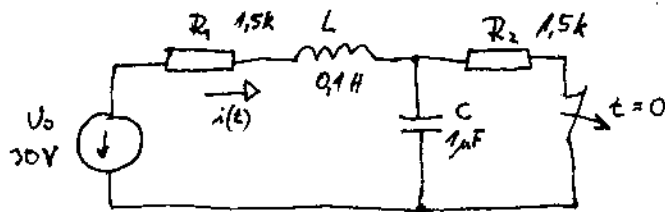
$$u_{c0} = k e^{-\frac{1}{CR_2} t} = k e^{-157 t}$$

$$u_{cf} = 0$$

$$u_c = k e^{-157 t} = 9,06 e^{-157 t}$$

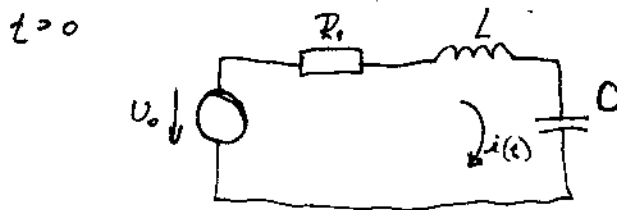
$$9,06 = k$$

2.2.1



$$u_0(0) = U_0 \cdot \frac{R_2}{R_1 + R_2} = 15V$$

$$i_i(0) = \frac{U_0}{R_1 + R_2} = 10 \text{ mA}$$



$$i(t): \frac{-U_0}{p} + R_1 I(p) + pL I(p) - L i_i(0) + \frac{1}{pC} I(p) + \frac{u_0(0)}{p} = 0$$

$$\frac{-30}{p} + 1500 I(p) + 0.1 p I(p) - 0.001 + \frac{I(p)}{p} \cdot 10^6 + \frac{15}{p} = 0$$

$$I(p) \left(1500 + 0.1p + \frac{10^6}{p} \right) = \frac{30}{p} + 0.001 - \frac{15}{p}$$

$$I(p) \left(\frac{1500p + 0.1p^2 + 10^6}{p} \right) = \frac{15 + 0.001p}{p}$$

razbiju. metoda

$$A = \frac{15 + 0.001p}{p + 2 \cdot 10^3} \Big|_{p = -10^3}$$

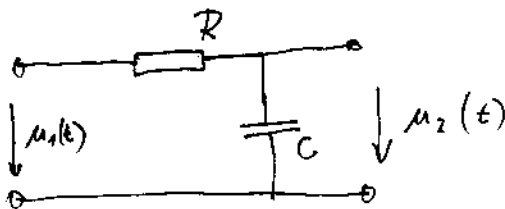
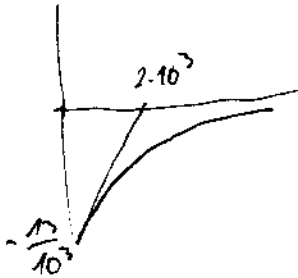
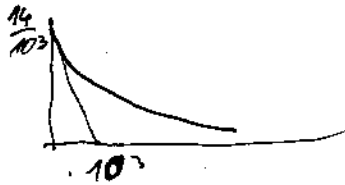
$$= \frac{15 - 1}{10^3} = \frac{14}{10^3}$$

$$B = \frac{15 - 2}{p + 10^3} = \frac{13}{p + 10^3}$$

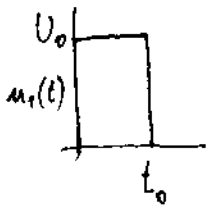
$$I(p) = \frac{15 + 0.001p}{0.1p^2 + 1500p + 10^6} = \frac{A}{(p + 10^3)(p + 2 \cdot 10^3)} = \frac{A}{p + 10^3} + \frac{B}{p + 2 \cdot 10^3} = \frac{14 \cdot 10^{-3}}{p + 10^3} + \frac{-13 \cdot 10^{-3}}{p + 2 \cdot 10^3}$$

$$i(t) = \frac{14}{10^3} \cdot e^{-10^3 t} - \frac{17}{10^3} e^{-2 \cdot 10^3 t}$$

$$\mathcal{L}^{-1} \left\{ \frac{a}{p+b} \right\} = a \cdot e^{-b \cdot t}$$



$$a(t) = \mathcal{L}^{-1} \left\{ \frac{P(p)}{Q} \right\} \quad \text{přechodová charakteristika}$$



$$u_1(t) = 1(t) U_0 - 1(t-t_0) U_0$$

$$p = \frac{\frac{1}{RC}}{R + \frac{1}{RC}} = \frac{1}{RC + 1}$$

$$A + B(RC + 1) = 1$$

$$K: B = 1$$

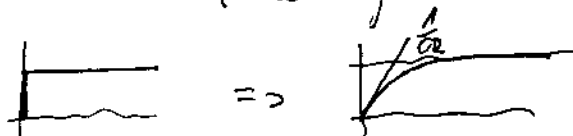
$$f: A + B \cdot CR = 0$$

$$A = -CR$$

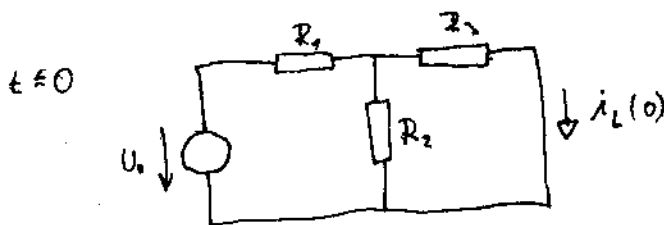
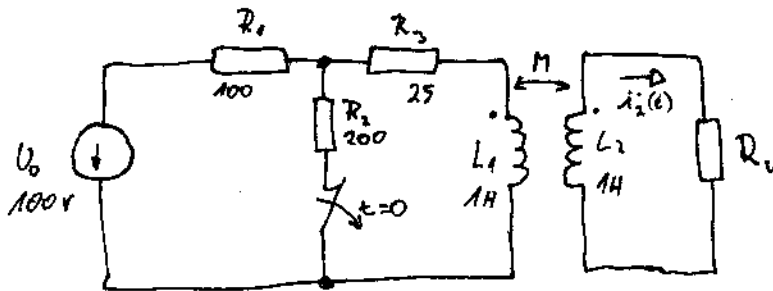
$$\frac{1}{(RC + 1)p} = \frac{A}{RCp} + \frac{B}{p} = \frac{-CR}{RCp + 1} + \frac{1}{p} =$$

$$= \frac{-1}{p + \frac{1}{CR}} + \frac{1}{p}$$

$$a(t) = 1(t) \left(1 - e^{-\frac{t}{CR}} \right)$$



$$u_2(t) = U_0 \cdot 1(t) \cdot \left(1 - e^{-\frac{1}{CR}t}\right) - U_0 \cdot 1(t-t_0) \left(1 - e^{-\frac{t-t_0}{CR}}\right)$$



$$R_3 = \frac{200 \cdot 25}{225} = \frac{5000}{225}$$

~~Resistor value~~

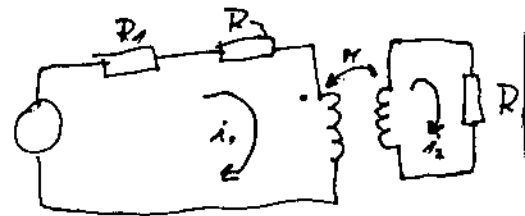
~~Calculation~~

$$i_{L1}(0) = U_0 \cdot \frac{R_3 \parallel R_2}{R_1 + R_3 \parallel R_2} \cdot \frac{1}{R_3} = 0,73 \text{ A}$$

$$i_{L2}(0) = 0 \text{ A}$$

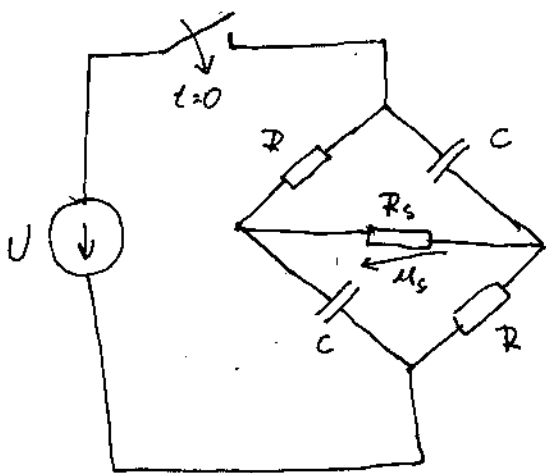
$t > 0$

$$i_1: -\frac{U_0}{R_1} + (R_1 + R_3) I_1(p) + p L_1 I_1(p) - M I_2(p) - L_1 i_1(0+) = 0$$

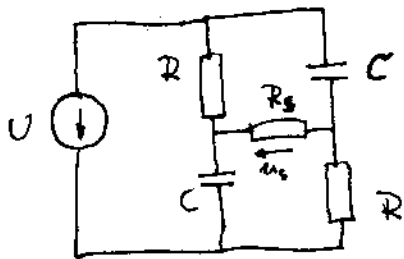


$$i_2: p L_2 I_2(p) - M I_1(p) - L_2 i_2(0+) + M I_1(0+) + R_4 I_2(p) = 0$$

moșina la jale doreșit

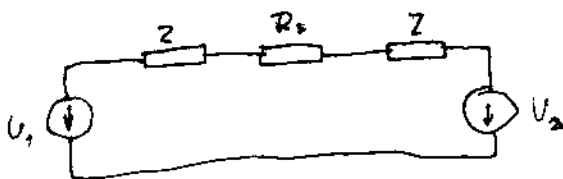


$$u_s(t) = ?$$



$$Z = \frac{1}{\frac{1}{RC} + \frac{1}{R}} = \frac{1}{\frac{RC+1}{R}} = \frac{R}{RC+1}$$

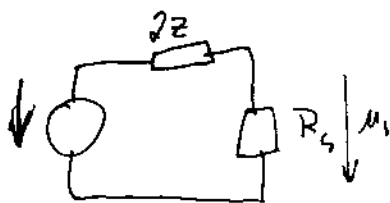
Thévenin



$$U_1 = U \frac{\frac{1}{RC}}{\frac{1}{RC} + R} = U \frac{1}{1 + RC}$$

$$U_2 = U \frac{R}{\frac{1}{RC} + R} = U \frac{1}{\frac{1}{RC} + 1} = \frac{U \frac{RC}{1 + RC}}{\frac{RC}{1 + RC}}$$

a.p. superposition



$$u_s = U_2 \frac{R_s}{2Z + R_s} - U_1 \frac{R_s}{2Z + R_s} = \frac{U \frac{RC}{1 + RC} \cdot \frac{R_s}{\frac{2R}{RC+1} + 1 + R_s}}{\frac{2R}{RC+1} + 1 + R_s} - \frac{U}{1 + RC} \cdot \frac{R_s}{\frac{2R}{RC+1} + 1 + R_s} =$$

$$= \frac{UR_s(\mu RC - 1)}{2R + R_s\mu CR + R_s} - \frac{UR_s(\mu CR - 1)}{2R + R_s + R_s\mu CR}$$

$$A(\mu) = \frac{1}{\mu} \cdot \frac{UR_s(\mu CR - 1)}{(2R + R_s) + R_s\mu CR} = \frac{A}{\mu} + \frac{B}{(2R + R_s) + R_s\mu CR}$$

$$A = \frac{-UR_s}{2R + R_s}$$

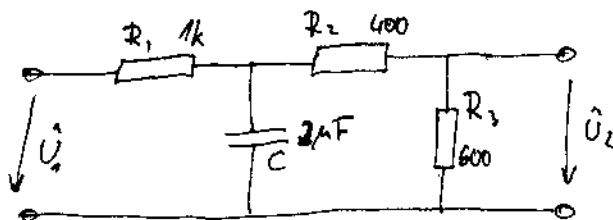
$$B = \frac{UR_s \left(\frac{-2R - R_s}{R_s CR} \cdot RC - 1 \right)}{-2R - R_s \frac{R_s}{R_s CR}} = \frac{UR_s \left(\frac{-2R - R_s}{R_s CR} \cdot RC - 1 \right)}{-2R - R_s \frac{R_s}{R_s CR}}$$

DÚ 2.2.8-b

+ DODO

přístě stejná možnost

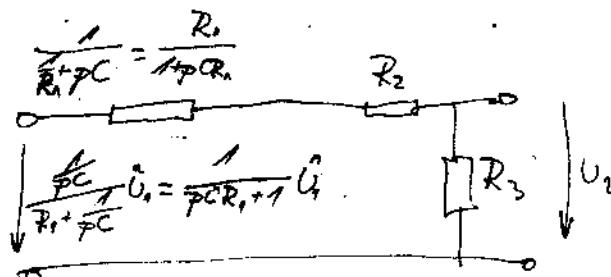
Ú 2.3.1



$$u(t) = ? = \mathcal{L}^{-1} \{ P(f) \}$$

$$a(t) = ? = \mathcal{L}^{-1} \left\{ \frac{1}{p} \cdot P(p) \right\}$$

Thévenin



$$P(p) = \frac{R_2}{\frac{R_1}{1+pCR_1} + R_2 + R_3} \cdot \frac{1}{1+pCR_1} = \frac{R_2}{R_1 + (R_2 + R_3)(1+pCR_1)}$$

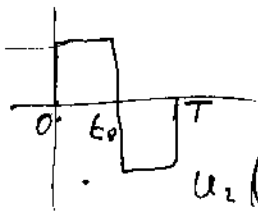
$$= \frac{R_2}{R_1 + R_2 + R_3 + pCR_1R_2 + pCR_1R_3} = \frac{R_2}{R_1 + R_2 + R_3 + p(CR_1R_2 + CR_1R_3)}$$

$$= \frac{\frac{R_2}{CR_1R_2 + CR_1R_3}}{p + \frac{R_1 + R_2 + R_3}{CR_1R_2 + CR_1R_3}} = \left\{ \frac{300}{p + 1000} \right\}$$

$$w_{th}(t) = \frac{R_2}{CR_1R_2 + CR_1R_3} \cdot e^{-\frac{R_1 + R_2 + R_3}{CR_1R_2 + CR_1R_3} t}$$

$$a(t) = \mathcal{L}^{-1} \left\{ \frac{1}{p} \cdot \frac{300}{p + 1000} \right\} = \mathcal{L}^{-1} \left\{ \frac{-0,3}{p + 1000} + \frac{0,3}{p} \right\} =$$

$$= 0,3 (1 - e^{-1000t}) \underline{1}(t)$$

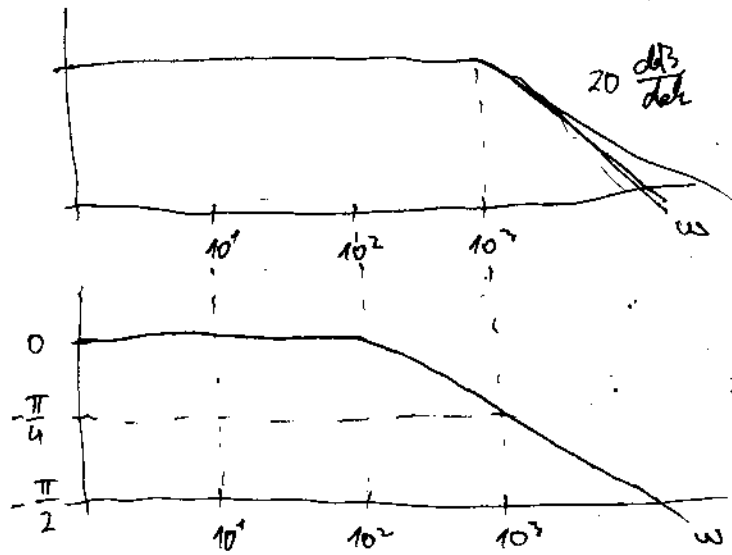


$$u_2(t) = U_0 \cdot 0,3 (1 - e^{-1000t}) \underline{1}(t) - 2U_0 \cdot 0,3 (1 - e^{-1000(t-t_0)}) \underline{1}(t-t_0) + U_0 \cdot 0,3 (1 - e^{-1000(t-T)}) \underline{1}(t-T)$$

$$P = \frac{300}{p + 1000} \quad ; \quad p = j\omega \quad = \frac{300}{j\omega + 1000} = \frac{0,3}{1 + \frac{j\omega}{1000}}$$

fol: $\omega_0 = 1000$

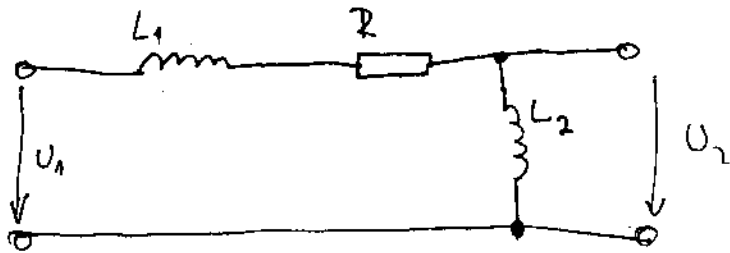
$$\left(\frac{j \frac{\omega}{\omega_0}}{1 + j \frac{\omega}{\omega_0}} \right)$$



$$\frac{(1 + j\frac{\omega}{\omega_1})(1 + j\frac{\omega}{\omega_2})}{(1 + j\frac{\omega}{\omega_3})(1 + j\frac{\omega}{\omega_4})}$$

nuly (zeros) and *poly* (poles) are indicated.

Ü 2.4.3

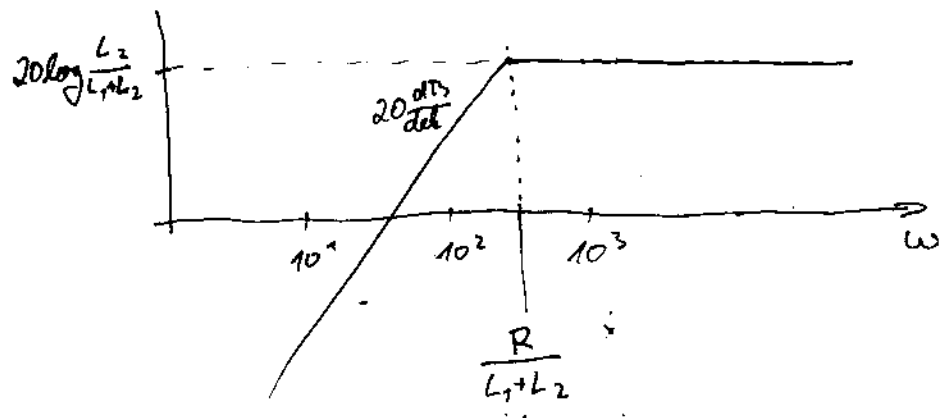


$$P = \frac{\varphi L_2}{\varphi L_1 + \varphi L_2 + R} = \frac{\varphi L_2}{\varphi(L_1 + L_2) + R}$$

$$\frac{j\omega L_2}{j\omega(L_1 + L_2) + R} = \frac{j\omega L_2}{1 + j\frac{\omega R}{L_1 + L_2}} = \frac{\frac{L_2}{L_1 + L_2} j\frac{\omega R}{L_1 + L_2}}{1 + j\frac{\omega R}{L_1 + L_2}}$$

sem dostat woco doll (pointing to the $j\omega L_2$ term)

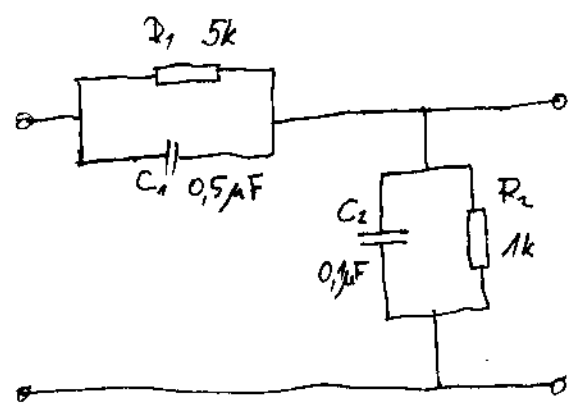
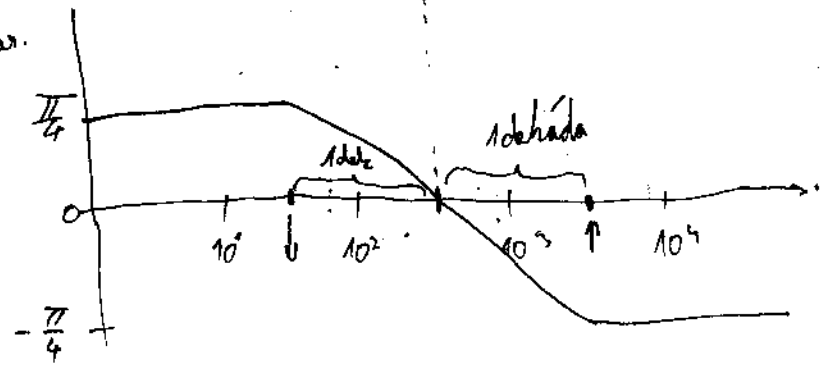
modulová
fázová char.



$$\lg \left(A_0 \frac{j\omega}{1 + j\frac{\omega}{\omega_0}} \right)$$

$$= \lg A_0 + \lg j\frac{\omega}{\omega_0} - \lg \left(1 + j\frac{\omega}{\omega_0} \right)$$

fázová char.



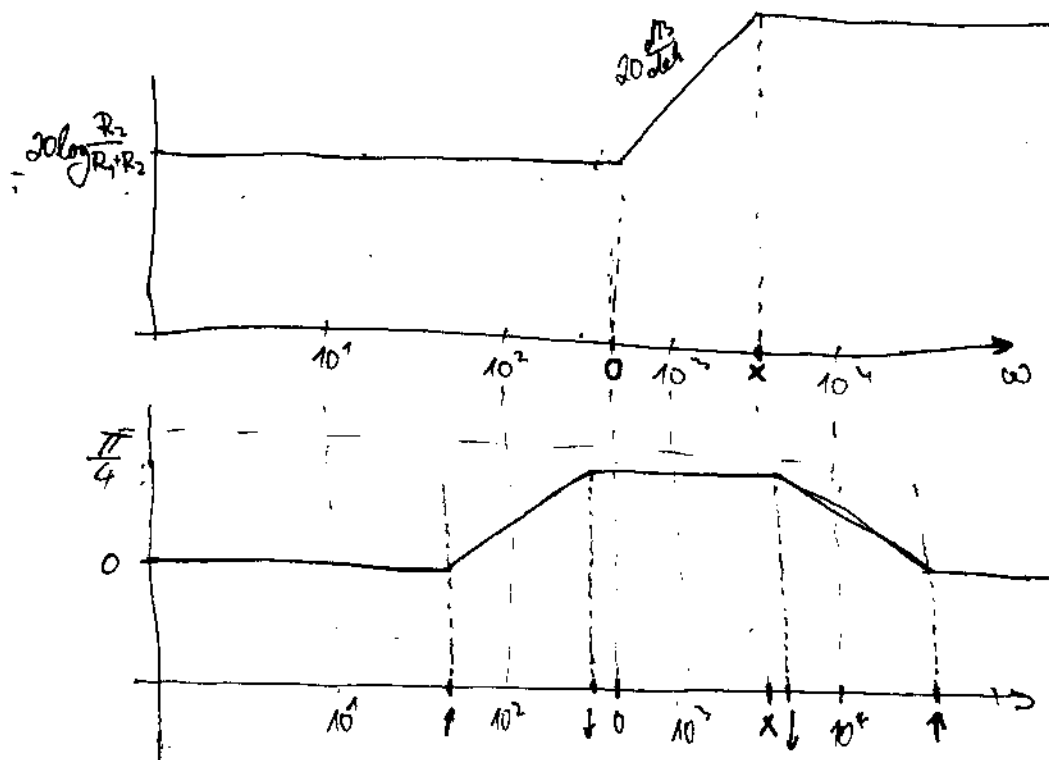
$$\Phi = \frac{\frac{1}{\frac{1}{R_2} + pC_2}}{\frac{1}{\frac{1}{R_2} + pC_2} + \frac{1}{\frac{1}{R_1} + pC_1}} = \frac{\frac{1}{R_2} + pC_1}{\frac{1}{R_2} + pC_1 + \frac{1}{R_2} + pC_2} =$$

$$= \frac{R_2(1 + pC_1R_2)}{R_2(1 + pC_1R_1) + R_1(1 + pC_2R_2)} = \frac{R_2 + pC_1R_1R_2}{R_2 + R_1 + p(C_1R_1R_2 + C_2R_2R_1)}$$

$$= \frac{R_2 \left(1 + j\omega C_1 R_2 \right)}{(R_1 + R_2) \left(1 + j \frac{\omega C_1 R_1 R_2 + C_2 R_2 R_1}{R_1 + R_2} \right)}$$

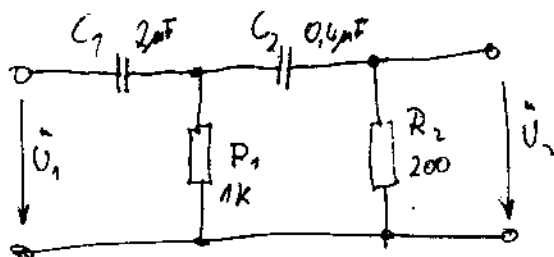
$$0: \omega_0 = \frac{1}{C_1 R_1} = 400$$

$$X: \omega_1 = \frac{R_1 + R_2}{R_1 R_2 (C_1 + C_2)} = 2000$$

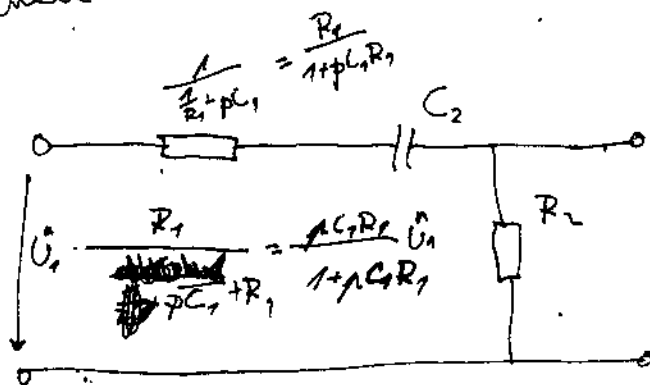


erste Laborzug 6.1.2

2.4.7



Thevenin



$$\frac{U_2}{U_1} = \frac{R_2}{\frac{R_1}{1+\mu C_1 R_1} + \frac{1}{\mu C_2} + R_2} \cdot \frac{\mu C_1 R_1}{1+\mu C_1 R_1} =$$

$$= \frac{\mu C_1 R_1 R_2}{R_1 + \frac{1+\mu C_1 R_1}{\mu C_2} + R_2 + \mu C_1 R_1 R_2} =$$

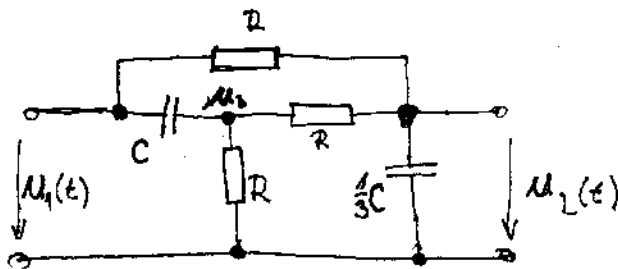
$$= \frac{\mu^2 C_1 R_1 R_2 C_2}{R_1 \mu C_2 + 1 + \mu C_1 R_1 + R_2 \mu C_2 + \mu^2 C_1 C_2 R_1 R_2}$$

$$= \frac{\mu^2 C_1 C_2 R_1 R_2}{\mu^2 C_1 C_2 R_1 R_2 + \mu (R_1 C_2 + C_1 R_1 + R_2 C_2) + 1}$$

DODO

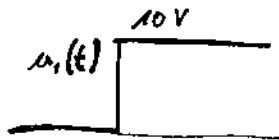
DÚ 2.4.12
2.3.6

4.2.4



$$R = 1 \text{ k}\Omega$$

$$C = 1 \mu\text{F}$$



$$u_1: \quad C \frac{d(u_2 - u_1)}{dt} + \frac{u_3 - u_2}{R} + \frac{u_3}{R} = 0$$

$$u_2: \quad \frac{1}{3}C \frac{du_2}{dt} + \frac{u_2 - u_3}{R} + \frac{u_2 - u_1}{R} = 0 \Rightarrow \frac{1}{3}RC \frac{du_2}{dt} + 2u_2 - u_1 = u_3$$

$$\frac{du_3}{dt} = \frac{1}{3}RC \frac{d^2u_2}{dt^2} + 2 \frac{du_2}{dt} - \frac{du_1}{dt}$$

$$\rightarrow RC \frac{du_2}{dt} - \frac{du_1}{dt} RC + 2u_3 - u_2 = 0 \quad \text{dasadit}$$

$$RC \left(\frac{1}{3}RC \frac{d^2u_2}{dt^2} + 2 \frac{du_2}{dt} - \frac{du_1}{dt} \right) - \frac{du_1}{dt} RC + 2 \cdot \frac{1}{3}RC \frac{du_2}{dt} + 4u_2 - 2u_1 - u_2 =$$

$$\frac{1}{3}R^2C^2 \frac{d^2u_2}{dt^2} + \frac{8}{3}RC \frac{du_2}{dt} = 2RC \frac{du_1}{dt} - 3u_2 + 2u_1 \quad \text{20V}$$

$$\frac{1}{3}R^2C^2 \frac{d^2u_2}{dt^2} + \frac{8}{3}RC \frac{du_2}{dt} + 3u_2 = 2U_1$$

$$\frac{d^2u_2}{dt^2} + \frac{8}{RC} \frac{du_2}{dt} + \frac{9}{R^2C^2} u_2 = \frac{6U_1}{R^2C^2}$$

$$\lambda^2 + \frac{8}{RC} \lambda + \frac{9}{R^2C^2} = 0$$

$$\lambda_{1,2} = \frac{-\frac{8}{RC} \pm \sqrt{\frac{64}{R^2C^2} - \frac{36}{R^2C^2}}}{2} = \frac{-\frac{8}{RC} \pm \frac{4\sqrt{2}}{RC}}{2} = -\frac{4}{RC} \pm \frac{2\sqrt{2}}{RC}$$

$$\lambda_1 = -\frac{1}{0,738} ; \lambda_2 = -\frac{1}{0,15}$$

$$u_2(0) = 0$$

$$\left. \frac{du_2}{dt} \right|_{t=0} = 60000$$

$$\begin{aligned} \frac{du_2}{dt} &= -\frac{3}{RC} (2u_2 - u_3 - u_1) = +\frac{3}{RC} (u_3 + u_1) = \\ &= \frac{3}{RC} (10 + 10) = 60 \cdot 10^{-3} \end{aligned}$$

$= 10 \text{ A} \cdot 10^{-3} \text{ s} = 10^{-2} \text{ s}$

$$\begin{aligned} u_2 &= k_1 e^{\lambda_1 t} + k_2 e^{\lambda_2 t} + \frac{20}{3} \\ &= k_1 e^{-\frac{1}{0,738} t} + k_2 e^{-\frac{1}{0,15} t} + \frac{20}{3} \end{aligned}$$

$u_2(t \rightarrow \infty) = \frac{20}{3}$

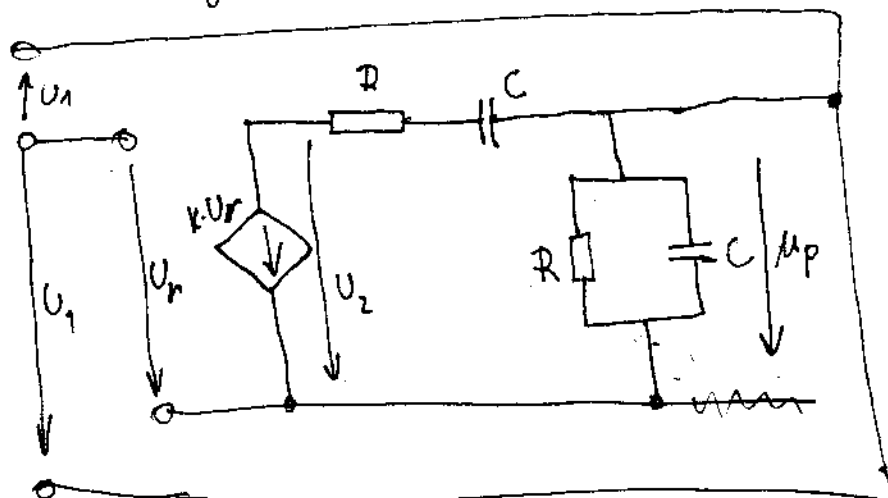
$$\frac{du_2}{dt} = -\frac{1}{0,738} k_1 e^{-\frac{1}{0,738} t} + \frac{1}{0,15} k_2 e^{-\frac{1}{0,15} t}$$

$$\begin{aligned} k_1 + k_2 + \frac{20}{3} &= 0 \\ -\frac{1}{0,738} k_1 - \frac{1}{0,15} k_2 &= 60000 \quad | \cdot 0,15 \\ -0,203 k_1 - k_2 &= 9000 \\ \hline k_1(1 - 0,203) + \frac{20}{3} &= 9000 \end{aligned}$$

môžna získať výsledky
postupom dobre

2.3.6

výběr stabilizátoru ~~stabilizátor~~ $\int_0^{\infty} \omega(t) dt < \infty \Leftrightarrow$ stabilizátor $\Leftrightarrow$ polynomiální $\Leftrightarrow$



$$k=2$$

$$R = 1 \text{ k}\Omega$$

$$C = 0.1 \mu\text{F}$$

$$\Rightarrow RC = 10^{-4}$$

$$p' = \frac{u_p}{u_2} =$$

$$= \frac{\frac{\frac{R}{pC}}{R + \frac{1}{pC}}}{R + \frac{1}{pC} + \frac{\frac{R}{pC}}{R + \frac{1}{pC}}} =$$

$$\begin{aligned} &= \frac{pCR}{pCR^2 + 3pCR + 1} = \frac{u_1 - u_2}{u_2} = \frac{\frac{u_2}{2} - u_1}{u_2} = \frac{u_2 - 2u_1}{2u_2} \\ &= \frac{1}{2} - \frac{u_1}{u_2} \end{aligned}$$

$$\Rightarrow \frac{pCR}{pCR^2 + 3pCR + 1} - \frac{1}{2} = -\frac{u_1}{u_2}$$

$$\frac{2pCR - pCR^2 - 3pCR - 1}{2(pCR^2 + 3pCR + 1)} = -\frac{u_1}{u_2}$$

$$\Rightarrow \frac{\mu_2}{\mu_1} = \frac{-\frac{1}{2}(p_{CR}^2 + 3p_{CR} + 1)}{kp_{CR} - p_{CR}^2 - 3p_{CR} - 1}$$

$$kp_{CR} - (p_{CR})^2 - 3p_{CR} - 1 = 0$$

$$(p_{CR})^2 + p_{CR} + 1 = 0$$

stačí jeden kladný kořen, aby nestabilní

příště měření

L6.3.1 + L6.3.2